Executive Summary

This report provides a summary of water quality data collected between 2005 and 2007 as part of King County's ambient and outfall marine monitoring program. The monitoring program contains elements of baseline sampling to assess background conditions (ambient monitoring) and also sampling to assess conditions around the County's marine outfalls (point source monitoring). Data are assessed at three secondary wastewater treatment plant (TP) marine outfalls (West Point TP, South TP, and Vashon TP), three combined sewer overflow (CSO) treatment facilities (Alki TP, Carkeek TP, and Elliott West TP), and selected CSO outfalls as part of the point source monitoring program. The County's marine monitoring program is part of an inter-governmental Puget Sound monitoring effort, the Puget Sound Assessment and Monitoring Program (PSAMP).

In 2005, 12 outfall stations (6 offshore and 6 beach) and 20 ambient stations (5 offshore and 15 beach/creek) were sampled. In 2006, 32 outfall stations (26 offshore and 6 beach) and 18 ambient stations (7 offshore and 11 beach/creek) were sampled. In 2007, 12 outfall stations (6 offshore and 6 beach) and 40 ambient stations (18 offshore and 22 beach/creek) were sampled.

Offshore water samples were collected monthly and analyzed for fecal indicator bacteria, nutrients, temperature, salinity, dissolved oxygen, turbidity/light transmission, water clarity, suspended solids, photosynthetically active radiation (PAR), and chlorophyll. Beach waters were collected monthly and analyzed for fecal indicator bacteria, nutrients, temperature, and salinity.

Beach sediments were collected only in 2005 as this program is now conducted on a five-year monitoring cycle. Sediment conventionals, organic compounds, and metals were analyzed in the beach sediments. Nineteen sediment samples were collected at the West Point TP outfall in 2006 and analyzed for sediment conventionals, organic compounds, and metals. In addition, benthic community structure and abundance was assessed at 11 of the 19 West Point TP outfall sites. Fourteen subtidal sediment samples were collected in 2007 at ambient sites, of which eight were located in Elliott Bay, and analyzed for sediment conventionals, organic compounds, and metals.

Butter clam tissues were collected at seven sites in 2005 and at eight sites in 2006 and 2007. In 2005, butter clams were collected in August and starting in 2006, clams were also collected in March to assess seasonal differences. Macroalgae samples, consisting of the green alga *Ulva sp*. were collected in 2005 and analyzed for metals. Macroalgae sampling was subsequently discontinued due to limited data usage.

Climate Data

In terms of precipitation, 2005 and 2007 were typical years when compared to the 30-year(yr) average. However, a total of 48.42 inches of rain fell in 2006 which is more than 15 inches above the 30-yr average and the second highest on record since 1969. Average monthly air temperatures in 2005 and mid-2007 were typical when compared to the 30-yr average. Warmer

than normal air temperatures were seen from May to September in 2006. In September 2006, a mild El Niño event developed in the Pacific Ocean, which dissipated in early 2007. Warmer air temperatures preceding this El Niño event were apparent in June and July of 2006.

Monitoring Results

Water

In general, water quality monitoring results were consistent with past findings and indicated the following:

- Fecal coliform bacteria in offshore waters were consistently low and all samples collected between 2005 and 2007 met the State standards, with the majority of samples having either no detectable levels or 1 colony forming unit (CFU)/100 ml.
- Fecal coliform counts in Elliott Bay and Quartermaster Harbor were higher more frequently than other offshore stations, with 58% of the Elliott Bay and 33% of the Quartermaster Harbor samples having values of 2 CFU/100 ml or higher compared to 11% for other offshore sites.
- There was no difference between fecal coliform levels at outfall stations as compared to ambient stations.
- Fecal coliform levels at beach stations varied between stations and year and no spatial or seasonal pattern was detected.
- The beach stations that most frequently exceeded the State standards were at Redondo, Des Moines Creek Park, and Dumas Bay.
- In all three years, a seasonal thermocline developed at offshore stations between April and June. The thermoclines were much more pronounced in 2006 due to El Niño conditions in mid-2006.
- During the winter months at beach stations, the coldest water temperatures were seen at sites with the most freshwater input, Shilshole Bay, Piper's Creek, and the Seattle waterfront. However, in January 2007 ice was observed floating in Quartermaster Harbor near Burton Acres where a temperature of 4.1^{o}C was observed.
- The cycle of coastal upwelling along the outer Pacific coast is seen as a deep, salty signal in late summer and fall of each year in the Central Basin.
- Maximums in dissolved oxygen correspond with maximums in chlorophyll-*a* concentration, temporally and spatially, in the upper 25 meters of the water column.
- Seasonal variations throughout the water column indicate the entrance of low-oxygenated Pacific Ocean water and consumption of oxygen by bacterial respiration in the deep basin over late summer and fall.
- For all three years at all stations, most dissolved oxygen concentrations were above 5.0 mg/L. In 2005, all values were above 5.0 mg/L, including the Elliott Bay stations which typically had values less than 5.0 mg/L in the late summer and early fall months in previous years.
- Low dissolved oxygen values were seen in 2006 and 2007 at the Quartermaster Harbor stations, including a value of 3.6 mg/L in September 2007. This low oxygen level is of concern as biological stress may be induced.

- All ammonia concentrations were well below the Washington State chronic criterion. The highest concentrations in offshore waters in 2005 and 2006 were detected at the West Point and South Plant outfalls, respectively, at the trapping depth of each effluent plume. In 2007, the highest value was detected in Quartermaster Harbor following a large phytoplankton bloom.
- Ammonia values at beach stations were usually higher during the summer months, particularly during times when large amounts of decaying seaweed along the shoreline occur. This was particularly evident in July 2006 due to warm air temperatures causing optimal seaweed growth.
- Seasonal variations in nitrate+nitrite concentrations in the photic zone correspond to phytoplankton production in the water column.
- Nitrate+nitrite concentrations in beach waters were slightly higher than those at offshore stations and showed seasonal fluctuations corresponding to marine vegetation growth cycles.
- In 2005 and 2006, silica was below detectable levels at several stations which is an unusual occurrence. In both years, the undetectable levels occurred during the second large phytoplankton bloom of the year indicating that silica likely became the limiting growth factor rather than nitrogen.
- The spring phytoplankton bloom occurred in April during all three years. Phytoplankton blooms in the southern portion of the Central Basin occurred both earlier and later in the year than in other areas.

Sediment

The beach (intertidal) sediment program, as an annual event, was sampled for the final time in 2005. Subsequent to 2005, the beach sediment program will be sampled once every five years. Results from the 2005 beach sediment sampling event indicate that:

- Sediments collected from all eight stations (four outfall and four ambient) were comprised mainly of sand and gravel.
- Four of the 14 metals analyzed – arsenic, cadmium, selenium, and silver – were not detected in any of the samples. All other metals were detected at concentrations indicative of natural background concentrations. All concentrations of those metals regulated under the Washington State Sediment Management Standards (SMS) were well below their respective chemical criteria.
- Out of the 99 organic chemicals analyzed, only 19 were detected. Pesticides and PCBs were not detected in any of the samples. All detected concentrations of organic chemicals were well below their respective SMS chemical criteria and/or sediment quality values (Lowest Apparent Effects Thresholds or LAET).

Sediment samples were collected from 19 stations at the West Point TP in 2006 to meet requirements of the County's NPDES permit. Results from chemical and biological analysis of these sediments indicate that:

- There were no exceedences of SMS or LAET sediment quality criteria/values for those compounds regulated under SMS.

- Polybrominated flame retardants (PBDEs) were detected in all nine samples analyzed. PBDE concentrations detected at West Point were similar in range to concentrations detected at ambient monitoring stations in Puget Sound.
- The benthic infaunal community near the West Point outfall is robust, with a diverse and abundant population.

Fourteen stations in Elliott Bay, the Central Basin, and selected embayments were sampled in 2007 as part of the ambient subtidal sediment monitoring program. Results from the 2007 ambient subtidal sediment sampling event indicate that:

- Mercury concentrations at two stations, located in Quartermaster Harbor and offshore of Harbor Island in Elliott Bay, exceeded the SMS chemical criterion. Concentrations of mercury at the other 12 stations, as well as concentrations of the other 7 regulated metals, were all below their respective chemical criteria.
- Concentrations of arsenic, cadmium, and lead were elevated in Quartermaster Harbor compared to other stations, but did not exceed SMS criteria. Stack emissions from the former Asarco Smelter in Tacoma may have lead to the elevated concentrations of arsenic, cadmium, lead, and mercury in Quartermaster Harbor.
- The concentration of benzyl butyl phthalate detected at the Harbor Island station exceeded the SQS. The concentration of bis(2-ethylhexyl) phthalate detected at the station located in East Passage exceeded the cleanup screening level (CSL) chemical criterion. Concentrations of all other organic compounds were below their respective chemical criteria.
- PCBs were detected at 13 of 14 stations and, at stations removed from direct anthropogenic inputs, correlated well with the percent of fine material in the sediment. The highest PCB concentrations were detected in Elliott Bay.
- One or more PAH compounds were detected at all 14 stations and, again, correlated well with the percent of fine material in the sediment at those stations removed from direct anthropogenic inputs. The highest total PAH concentrations were detected along the Seattle waterfront and at the station located in outer Salmon Bay, just outside of the Hiram Chittenden locks.
- Tributyltin was detected at 3 of 14 stations, all located in areas with heavy commercial vessel traffic and/or vessel maintenance drydocks; outer Salmon Bay, the Seattle waterfront, and Harbor Island.
- Polybrominated flame retardants (PBDEs) were detected in all 14 samples, with the highest concentration detected at the station in outer Salmon Bay.

Shellfish

Shellfish (butter clam) tissues were collected in August of all three years. Beginning in 2006, samples were also collected in March to assess seasonal differences. A minimum of five clams were collected at each site and composited into one sample. Results indicate the following:

- Metal concentrations in butter clams showed little variation for most metals, both spatially and temporally.

- Metal concentrations found in butter clams between 2005 and 2007 were low when compared to regulatory limits and in previous years.
- For most metal concentrations, there does not appear to be a seasonal difference between samples collected in March and August. Arsenic tended to be higher in samples in August.
- Organic compound were analyzed in 2005 and only 5 of the 97 compounds analyzed were detected. As so few organic compounds are detected in clam tissues, these analyses were discontinued after 2005.
- A PCB Aroclor, Aroclor 1254® was detected in one sample from the north side of Discovery Park (West Point) at a low concentration. PCBs had not been previously been detected in any shellfish tissues or sediment from this station.
- Beta-BHC, a chlorinated pesticide, was detected in four of seven samples. This compound was one of the three organics compounds previously detected in shellfish tissues. Although beta-BHC was a constituent in pesticide mixtures, it is now banned in the United States. However, beta-BHC is also a breakdown product of gamma-BHC (Lindane) which is still in use as an insecticide.

Macroalgae

Macroalgae samples consisting entirely of the green alga, *Ulva spp*. (also known as sea lettuce), were collected in August 2005 and analyzed for 14 metals. Results were consistent with past findings and indicated the following:

- Arsenic, cadmium, chromium, copper, lead, nickel, and zinc were detected in all samples but showed no spatial or temporal pattern.
- Selenium, beryllium, and silver were not detected in any samples, nor in past years.
- Mercury was detected in all three ambient samples but not in any of the outfall samples.
- Due to limited use of the data, the macroalgae sampling program was discontinued in 2006.

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